Coastal Ocean Modeling and Observation Program

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LONG-TERM GOAL

The long-term goal of our coordinated ONR/NOPP research efforts is the development of a relocatable coastal ocean forecasting system consisting of a coupled atmospheric-hydrodynamic-optical data-assimilative numerical model and a multi-platform real-time adaptive sampling network for use in physical/bio-optical applications worldwide.

OBJECTIVES

Specific current objectives include:(a) Implementation of a comprehensive coastal prediction system incorporating atmospheric, benthic and bio-optical submodels; (b) Construction of a shipboard/autonomous subsurface sampling network beneath spatially extensive remotely sensed surface observations; (c) Development of data-assimilative and visualization interfaces for model-directed adaptive sampling; and (d) Evaluation of nowcast/forecast skill in multiple regions.

APPROACH

We are conducting a series of Coastal Predictive Skill Experiments (CPSE) each summer at the Long-term Ecosystem Observatory (LEO-15) offshore Tuckerton, NJ. Model and observation network improvements tested each winter with existing data are used in an operational setting the following summer. Our phenomenological focus is on the recurrent upwelling centers that form along the southern New Jersey coast and their impact on phytoplankton distributions, in-water optical properties

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Coastal Ocean Modeling and Observation Program	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Rutgers University,Institute of Marine and Coastal Sciences,71 Dudley Road,New Brunswick,NJ,08901**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**5**	

and dissolved oxygen. Coordinated shipboard (physical and bio-optical) and multiple AUV adaptive sampling surveys of the upwelling centers are conducted based on the real-time observations and the model forecasts. To demonstrate relocatability, the model is being transitioned to the Gulf of Maine.

WORK COMPLETED

The Rutgers Regional Ocean Modeling System (ROMS) was configured for the New York Bight and run in real-time during the month of July, 1998. Forecasts were generated twice per week using an Optimal Interpolation (OI) data assimilation scheme and surface forcing from standard Navy atmospheric models (NORAPS/NOGAPS). The data types assimilated were increased approximately weekly, beginning with SST and CTD data, adding surface currents from CODAR, and finally adding subsurface currents from ship-towed ADCP surveys. Model sensitivities are now being assessed in preparation for next summer.

Additions to the existing real-time observation network included SeaWiFS color imagery, CODAR surface currents, autonomous operation of the LEO node ADCP/CTDs, a new SWATH tow-body for surface towing an ADCP, and a redesigned undulating tow-body for the shipboard CTD. Data from the observation network was processed, displayed on the World Wide Web, and made available for assimilation within a few hours of its collection. Nowcasts developed from the Web displays and forecasts from the model were used for adaptive sampling mission planning. Shipboard towed systems and REMUS AUVs were directed on multiple 20 km long parallel cross-shelf tracks through regions of interest. The REMUS Turbulence AUV was directed on shorter transects across fronts and through eddies. Webb Lagrangian Profilers were tested in deep and shallow water. The numerous datasets are now being post-processed for more detailed analysis, assimilation studies, and model validation.

Cross-shelf bio-optical transects were conducted in conjunction with the physical surveys. Measured downwelling spectral irradiances and diffuse attenuation coefficients were collected with a PRR-600 spectral radiometer and a TBS-OCR Satlantic. The inherent optical properties were collected using a Wetlabs ac-9. Absorption and fluorescence excitation/emission were measured with the Wetlabs SAFIRE. Optical systems functioned well at sea, including deployment of ac-9/Safire with and without 0.2 micron filters on the flow tube intake providing in situ estimates of total, dissolved and particulate optical signals. Discrete samples were collected for phytoplankton pigmentation, total suspended matter, and particulate organic carbon. Data and sample analysis is proceeding. A full radiative transfer program (Hydrolight 4.0) has been purchased and will be used to quantitatively link the apparent and inherent optical properties.

RESULTS

Wind forcing from the NORAPS/NOGAPS atmospheric models are in relatively good agreement with the observed Tuckerton winds during large scale upwelling favorable conditions associated with the Bermuda High, but the agreement is poor during the subsequent relaxation events or during rapidly changing frontal passages. Ocean model forecasts therefore are expected to be best during the initial phases of upwelling, a result confirmed this past summer by subsurface adaptive sampling surveys that recorded the surfacing of the thermocline north of LEO on the predicted day. Sensitivity to the poorly predicted but reduced wind forcing during the subsequent relaxation period is being studied. Model forecasts were strongly influenced by the assimilation of CODAR surface currents, so improved methods to extend this data vertically for assimilation are also being studied.

The experiment began during the relaxation of the first major upwelling event of the summer. The relaxation process was accompanied by a period of eddy formation and propagation as the warm surface water returned from offshore. This was followed by a quiescent period with very low winds and relatively flat isotherms throughout the study area. Stronger upwelling winds eventually returned, and the formation of a typical upwelling center was observed. Cross-shelf transects revealed a cyclonic eddy within the upwelling center, a meandering northward-flowing warm surface jet on the offshore side of the upwelling front, and a southward-flowing cold subsurface jet that hugged the coast. Maximum phytoplankton concentrations were observed in this subsurface jet. Information on internal tides and subsurface intensified inertial waves detected by the offshore mooring and the LEO node will now be used to refine the synoptic pictures of the subinertial flow from the parallel towed ADCP and REMUS surveys. The experiment ended with a mixing storm on the last day of July in which strong northeasterly winds and large waves destroyed the upwelling center and the near-shore stratification.

During upwelling variability in the bulk optical properties are closely tied to the evolving cyclonic eddy. Distinct optical fronts are observed which coincide with the sharp upwelling front offshore. The prominence of pigment signatures in the blue and red wavelengths becomes increasingly significant in the apparent and inherent optical properties over time during upwelling. Particulate absorption spectra resembled phytoplankton absorption spectra with distinct shoulders associated with chlorophyll a and accessory carotenoids. The importance of particulate absorption to total light absorption also increased with proximity to shore within the upwelled waters. Consistent with increased importance of phytoplankton to the overall bulk optical properties, light attenuation within the upwelling eddy could account for 84% of the variability in particulate organic carbon.

IMPACT/APPLICATION

A total of 13 Abstracts related to the summer 1998 experiment were submitted to the February ASLO conference in Santa Fe.

The discovery of the cold subsurface jet that was alive with phytoplankton has prompted a planned series of modeling studies to determine its larger structure and how the phytoplankton transported within it are entrained in the upwelling center. Sampling patterns with ships and multiple AUVs are being planned for next summer in an effort to simultaneously sample three parallel cross-shelf transects multiple times in one day. Lagrangian profilers are being considered for deployments in the near-shore jet. Methods for real-time communication of the shipboard towed data to improve coordination with bio-optical surveys are being explored.

The spectral database has allowed the derivation of optical models, which partition the bulk optical properties into its constituent members. This is significant given the heterogeneous optical signatures encountered in this nearshore coastal ocean site. The resulting algorithms will be key for both 1) validation of the Navy's hyperspectral COIS sensor which will be launched in the year 2000 and 2) providing the data inputs into a coupled optical-circulation model to be developed as part of the HyCODE program.

TRANSITIONS

The ocean circulation model developed for COMOP is being adapted to the Gulf of Maine by the USGS for ECOHAB applications. Towed ADCP and CTD systems developed here are being used by scientists from Rutgers and Stevens Inst. Tech. in estuary studies of Barnegat Bay (SeaGrant), Navesink River (NOAA/CMER) and Newark Bay (NJ-DEP). Scientists at Skidaway, Old Dominion and UMass have expressed interest in similar systems. The real-time display software developed for the undulating towed CTD data is now a standard product sold by Falmouth Scientific Inc. Optical approaches being developed as part of COMOP are being used in the NSF-NOAA EEGLE program, which, in part, is focused on sediment-dominated turbidity plumes in nearshore coastal environments. Many of the datasets collected for COMOP are displayed on our World Wide Web pages in near-real time. During the summer our Web access peaked at 33,000 hits per day, with a hit defined here as a mouse click on any of our pages. Over 90% of these hits were through commercial Internet access providers not associated with Rutgers.

RELATED PROJECTS

Two National Ocean Partnership Program (NOPP) grants were awarded to to enhance the summer Coastal Predictive Skill Experiments for 1998 and 1999. HyCODE has named LEO-15 one of two validation sites for the Coastal Ocean Imaging Spectrometer (COIS). In collaboration with Dr. Mark Moline (California Polytechnic) we are assessing the relative accuracy of derived products from the SeaWiFs satellite in the nearshore coastal ocean. With Dr. Paul Bissett and Curtis Davis (NRL), we are using the COMOP database to ground truth hyperspectral data collected by a Navy AVIRIS overflight during the 1998 field season. With Pablo Clemente-Colon of NOAA, we are using the COMOP database to groundtruth the SAR imagery from RADARSAT.

PUBLICATIONS

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Operational Periods for Sensors and Measurements at the LEO-15 Site - July, 1998